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ODONATA (DRAGONFLIES AND DAMSELFLIES) NAIADS IN SUB HIMALAYAN FOOTHILLS OF PAKISTAN

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ABSTRACT

A series of surveys were conducted during two consecutive years (2014-15) to explore the Odonata naiads from the sub-Himalaya of Pakistan and it revealed 23 species. Sub-order Anisoptera was represented by 16 species under 13 genera, and suborder Zygoptera represented 07 species under 05 genera. In Anisoptera, the family Libellulidae, followed by Aeshnidae and Gomphidae, was recorded as dominant. While in Zygoptera, the dominant family was recorded as Coenagrionidae, followed by Chlorocyphidae. For each recorded species, individual diagnosis, details like date of collection, number of male/females recorded, coordinates of locality, prevalent air temperature at localities, water body temperature, global distribution, and habitat description are provided. In Pakistan, taxonomic and faunistic studies on Odonata nymphs are highly limited and thus, it was decided to enhance knowledge over this ignored and neglected group by thoroughly surveying sub-Himalaya in Pakistan, which is less explored for biological surveys, especially for class Insecta. The manuscript brought forward a record of five naiads species for the first time from Pakistan.

Keywords: Naiads, Odonata, Anisoptera, Zygoptera, Sub Himalaya, Pakistan.

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INTRODUCTION

Odonates are an important predatory group of class Insecta. It includes dragonflies under suborder Anisoptera and damselflies under suborder Zygoptera; these suborders carry versatile importance (Mehmood *et al.,* 2020). Odonates are among the most ancient flying insects (Din *et al.,* 2013). They are hemi metamorphic, representing three life stages, i.e. egg, naiad, adult and enjoy two different lifestyles; aquatic as immature and terrestrial as an adult (Silsby, 2001). Naiads of Zygoptera can be separated from Anisoptera in having exposed gills and elongated bodies. They consume mosquito larvae, fish fries, and tadpoles thereby playing an important role in mosquito control and as important component of the natural food chain (Bhatti *et al.,* 2014; Zia *et al.,* 2018). It has been reported that a single naiad of *Pantala flavescens* Fabricius, 1798 of the family Libellulidae, can consume hundred mosquito larvae per day (Anjum, 1997). Morphologically, the head of Odonata naiads bears a pair of small antennae, compound eyes and possesses chewing type of mouthparts; their labium is like a long mask used to devour prey (Kalkman *et al.,* 2007).

Talking species complex, there is a record of more than 6500 described species of Odonata worldwide. Yet, most of the faunal works are based on adults. Taxonomic studies on Odonata naiads are very few, and there is a need to describe naiads worldwide. Fewer taxonomic studies on naiads have been done in many countries, including India (Nesemann *et al.,* 2011; Paul and Kakkassery, 2013), Nepal (Nesemann *et al.,* 2011), Bhutan (Nidup *et al.,* 2021; Dorji and Nidup, 2020) and Bangladesh (Kalkman *et al.,* 2020). According to Kalkman *et al.,* (2020), the aquatic stages of many odonate species and even many genera are still unknown. If we see for Pakistan, the Odonata naiad's species descriptions are very few. The major taxonomic works documenting larval records include (Anjum, 1997; Bhatti *et al.,* 2014; Din, 2012; Din *et al.,* 2013; Hussain, 1988; Hussain and Riaz, 1999 a, b; Hussain and Riaz, 2000; Hussain and Ahmed, 2004; Khaliq and Murtaza, 1994; Khaliq *et al.,* 1994 a, b; Khaliq *et al.,* 1995 a, b; Khaliq

and Siddique, 1995; Naeem, 2016; Yousuf *et al.,* 1995 and Yousuf *et al.,* 1996).

The Himalayas are a series of mountain ranges in South Asia (Fig. 1) that are spread over five countries, i.e., China (Tibet), Nepal, Bhutan, India and Pakistan (Khan, 2014). In Pakistan, the areas under the Himalayas are scarcely explored for Odonata (Zia, 2016). Besides the high peaks, the foothills of the Himalayas in Pakistan received little attention from taxonomists. To date, the only published work on Odonata of Sub Himalaya in Pakistan is the work of Zia (2016), who presented a thorough picture for Zygoptera adults inhabiting these foothills. Knowing the importance of these foothills for Odonata adults, the present study was designed as a primitive work to study naiads of Odonata inhabiting these foothills.

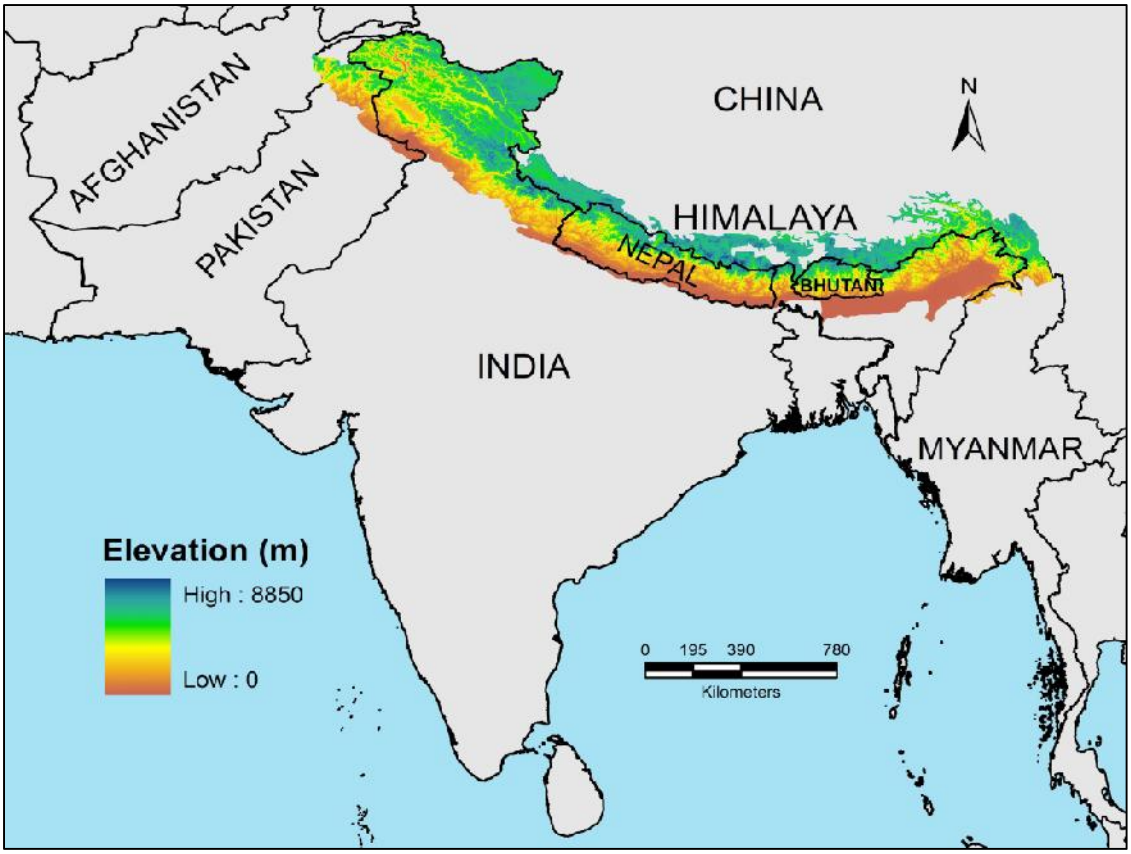

Fig. 1. Himalayan foothills location and positioning (Manish and Pandit, 2018).

MATERIALS AND METHODS

Surveys were conducted during the months of March to October during the years 2014 and 2015. As a whole, 33 localities were surveyed (Fig. 2). Naiads were recorded during 9 am to 7 pm from various lentic (ponds, basins, marshes, ditches, reservoirs, seeps, lakes, pools) and lotic (creeks, streams, rivers, springs, brooks, channels) habitats. Methods of sampling were based on Din (2012) with minor changes. D-net with approximately 0.5mm mesh size was used for collecting naiads in flowing water. However, in stagnant waters, sieving was done. For the sorting of naiads, white sorting pans were used. Freshly collected naiads were killed and preserved in 90% alcohol which, on bringing to the laboratory, were shifted to 70% alcohol, adding a few drops of glycerin to each vial to avoid hardening of body parts. For recording the temperature of water and air, wet and dry bulb thermometers were used, respectively. The latitude and altitude of the surveyed areas were recorded through Garmin GPSMAP 66S. Details for habitat type, water source, the temperature of positive localities, and the latitude and longitude of each locality were collected to get detailed information for recorded fauna.

Identification of the recorded fauna was carried out following (Anjum, 1997; Din, 2012; Hussain, 1988; Hussain and Riaz, 1999 a, b; Hussain and Riaz, 2000; Hussain and Ahmed, 2003; Hussain and Ahmed, 2004; Khaliq and Murtaza, 1994; Khaliq *et al.,* 1994 a, b; Khaliq *et al.,* 1995 a, b; Yousuf *et al.,* 1995; Yousuf *et al.,* 1996). Help was also taken from identified species, housed at National Insect Museum, National Agricultural Research Center (NARC) Islamabad, Pakistan. Identified

specimens are kept at The University of Agriculture Peshawar for future reference and study.

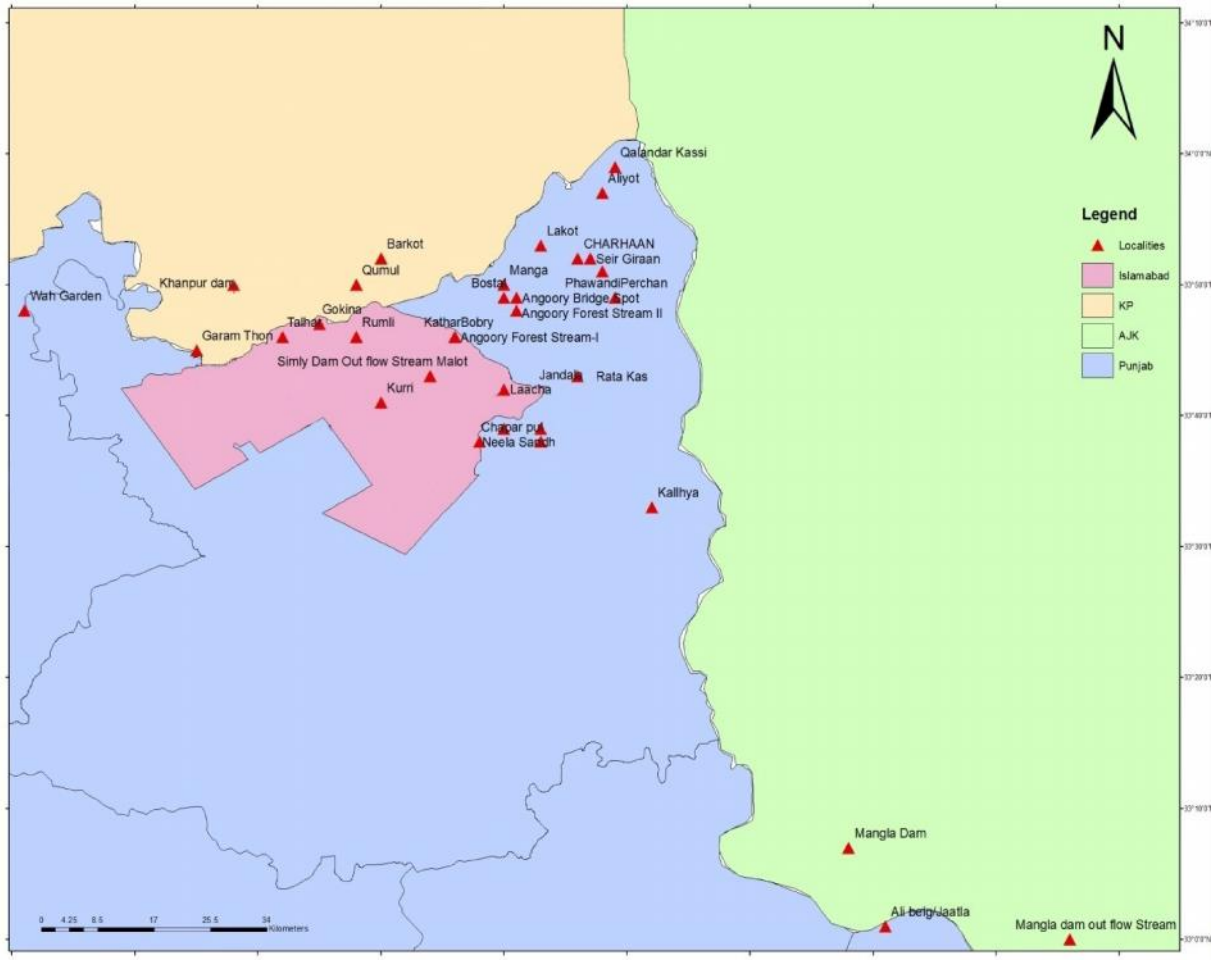

Fig. 2. Localities visited in Himalaya foothills of Pakistan to record Odonata naiads.

RESULTS

A total of 300 naiads were collected, revealing 23 species under 18 genera in 8 families and 2 suborders of order Odonata. Within suborder Anisoptera, 04 families spreading to 13 genera and 16 species were recorded. However for Zygoptera, 04 families spreading to 05 genera and 07 species were found. Details of each recorded taxa are presented below.

Suborder Anisoptera

Family Gomphidae

***Gomphidia t-nigrum* Selys, 1854**

Material examined: (n=3, 1♂, 2♀). Loc. Charhaan (4863ft., 33º52 N, 73º26 E) 29-x-2014, Leg. Naeem.

Description: These naiads are medium in size and blackish-brown in color. The head is small, almost as broad as long, the hind margins of the head are concave, and the 3rd antennal segment elongates at least four times longer than the width. Labial palpi's inner margins are hooked with four to five teeth. The abdomen is elongated and blackish brown; the lateral spine is present on segments 6-9.

Habitat: Naiads were collected from slow-moving waters with dense pine trees and wild flora all around. The dry temperature of the locality was 30°C, while that of water was recorded as 24°C.

Remarks: The morphology of this species and the habitat records match well with the description of Din (2012). The naiads of this species is reported from Jhelum and Attock by (Din *et al.,* 2013). However, the adults of this species are already documented from Punjab, Pakistan (Chaudhry *et al.,* 2016).

***Onychogomphus bistrigatus* Selys, 1854**

Material examined: (n=7, 3♂, 4♀). Loc. Talhar (3000ft., 33°46 N, 73°02 E) 2♂, 3♀, 30-ix-2014, Leg. Naeem; Loc. Wah Garden (3279ft., 33º48 N, 72º41 E) 1♂, 1♀, 11-ix-2014, Leg. Zia.

Description: These naiads are pale brownish in color. Head is rounded. Antennae are four segmented, the 3rd antennal segment moderately convex, only about three times as long as broad, but broader than the second segment. The abdomen is long pale brown in color with terga 9 and 10, approximately equal in length, with a mid-dorsal spine present on terga 6-9 and the abdomen bearing small spines.

Habitat: Naiads were recorded from the margins of river banks having long grasses and rock stones. The dry temperature of the locality was 30ºC, while that of the water body was recorded as 23ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan. The adults are already reported from Gilgit Baltistan and Punjab province (Chaudhry *et al.,* 2016), and Khyber Pakhtunkhwa (Rehman *et al.,* 2020).

Family Aeshnidae

***Anax immaculifrons* Rambur, 1842**

Material examined: (n=16, 9♂, 7♀). Loc. Angoory Bridge Spot (3835ft., 33º47 N, 73º21 E) 1♂, 2♀, 10-xi-2014, Leg. Rehman; Loc. Angoory Forest Stream I (2394ft., 33°46 N, 73°16 E) 3♂, 1♀, 20-vi-2014, Leg. Rehman; Loc. Kathar Bobry (3929ft., 33º 53 N, 73º 27 E) 3♂, 2♀, 28-viii-2014, Leg. Naeem; Loc. Seir Giraan (2706ft., 33º64 N, 73º18 E) 2♂, 1♀, 21-viii-2014, Leg. Iqbal.

Description: The bodies of these naiads are long and brownish in color. The head is flattened. The antenna is seven segmented; antennal segments are long and cylindrical. Labium is long and flat. Legs covered with ring-like black spots, wing pad parallel but not divergent. Abdominal spines are present on segments 7-9.

Habitat: Naiads were found from variable habitats like deep, shallow, stagnant and flowing waters. They were also found within a water pocket with two rocks carrying spring water. The dry temperature of the area was recorded to be 38ºC while that of the water body was 27ºC.

Remarks: The diagnosis of this species and the habitat records tally with the description of Din (2012). The naiads of this species are reported from Jhelum and Attock by (Din, 2012; Din *et al.,* 2013). However, the adults of this species are previously reported from Khyber Pakhtunkhwa and Azad Kashmir by (Chaudhry *et al.,* 2016).

***Aeshna juncea* Linnaeus, 1758**

Material examined: (n=09, 6♂, 3♀). Loc. Rata Kas (2750ft., 33°43 N, 73°27 E) 2♂, 2♀, 2-xi-2014, Leg. Naeem; Loc. Manga (3835ft., 33º50 N, 73º20 E) 3♂, 1♀, 16-viii-2014, Leg. Rehman; Loc. Qumul (3407ft., 33º51 N, 73º08 E) 1♂, 27-viii-2014. Leg. Rehman.

Description: Body yellowish and generally large. The head in the dorsal view is pentagonal. The antenna is six segmented; labium is flattened, not spoon-shaped. Prothorax narrow as compared to head, wing pads parallel. Legs long, with dark black markings. The hind leg is slightly longer than the pro and meso legs. Cercus is about half as long as paraproct.

Habitat: The source of naiad's collection was spring water. It was collected from small water ponds having thin vegetation cover. The dry temperature of the locality was 31ºC, while that of the water body was recorded as 23ºC.

Remarks: The diagnosis of this species and the habitat records match well with the description of Din *et al.* (2013). However, the adults of this species are previously reported from Khyber Pakhtunkhwa, Gilgit Baltistan and Azad Kashmir (Chaudhry, 2010; Chaudhry *et al.,* 2016).

Family Macromidae

***Macromia moorei* Selys, 1874**

Material examined: (n=07, 4♂, 3♀). Loc. Barkot (3346ft., 33º52 N, 73º10 E) 2♂, 3♀, 27-xiii-2014, Leg. Zia; Loc. Manga (3835ft., N, 33º50 N, 73º20 E) 2♂, 16-iii-2014, Leg. Rehman.

Description: These naiads are medium-sized and possess long legs like spiders. Head with a prominent frontal horn present between the bases of the antennae. Labial suture and labium in resting position reaching to procoxae. The prothorax is somewhat equal to the hind margins of the head, depressed interiorly and raised upward. Wing pads are parallel, with patches of dark spots present on each leg. The abdomen is the elongated pale brown lateral spine of segment nine that does not reach the tips of inferior appendages.

Habitat: Naiads were collected from streams running down the hills. On the sides of streams, dense vegetation of tall trees was present. The dry temperature of the locality was 30ºC, while that of the water body was recorded as 27ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan. The adults of this species are already documented from Punjab (Chaudhry *et al.,* 2016).

Family Libellulidae

***Acisoma panorpoides panorpoides* Rambur, 1842**

Material examined: (n=06, 4♂, 3♀). Loc. Khanpur dam (2002ft., 33°49 N, 72°55 E), 24-iv-2014, Leg. Iqbal.

Description: These naiads are short, stout and whole body covered with long hairs. The head is slightly narrowed posteriorly; antennae are filiform, the third segment longer than the fourth. The lateral abdominal spines are absent. Dorsal hooks are present on segments 4–9 and cerci about half the length of paraproct.

Habitat: These naiads were collected from a big water reservoir (dam out spill stream). Dense vegetation cover was present at the bank of the water reservoir. The dry temperature of the locality was 33ºC, while that of the water body was recorded 28ºC.

Remarks: The diagnosis of this species and the habitat records exactly match the description of (Din, 2012; Din *et al.,* 2013). This species is widely distributed throughout Pakistan. In previous studies, the adults of this species were recorded from all provinces of Pakistan (Chaudhry, 2010, Chaudhry *et al.,* 2016; Din *et al.,* 2013; Rehman *et al.,* 2020).

***Orthetrum taeniolatum* Schneider, 1845**

Material examined: (n=15, 8♂, 7♀) Loc. Chapar pul (1897ft., 33º39 N, 73º18 E) 3♂, 2♀, 2-xi-2014, Leg. Zia; Loc. Jandala (2665ft., 33º42 N, 73º25 E) 2♂, 2♀, 2-xi-2014, Leg. Rehman; Loc. Simly dam outflow stream (2010ft., 33°43 N, 73°14 E) 3♂, 3♀, 16-iv-2014, Leg. Naeem.

Description: These naiads are covered with long hairs, medium in size. The head is quadrangular in shape. Eyes are small, prominent, reaching to the bases of the antenna. Wing pads are always parallel, and the first and second pair of legs are almost equal in length. Abdomen elongate, the hook-like spines are present on tergum 4–9. Lateral abdominal spines are present on segments 8 and 9 and are almost equal in length.

Habitat: These naiads were collected from various habitats, i.e. lakes, ponds, slow-moving and standing water bodies. Small vegetation and dead leaves were observed in water, providing shelter to naiads. The dry temperature of the locality was 33ºC and while that of the water body was recorded 29ºC.

Remarks: The diagnosis of this species and the habitat records match well with the published description (Din, 2012 and Din *et al.,* 2013). In previous studies, its adults are documented from Punjab and Baluchistan (Chaudhry, 2010, Chaudhry *et al.,* 2016).

***Orthetrum sabina* Drury, 1770**

Material examined: (n=27, 18♂, 9♀) Loc. Simly dam outflow stream (2010ft., 33°43 N, 73°14 E) 7♂, 3♀, 16-vi-2014, Leg. Iqbal; Loc. Seir Giraan (2706ft., 33º64 N, 73º18 E) 6♂, 3♀, 10-vi-2014, Leg. Naeem; Loc. Chapar pul (1897ft., 33º39N, 73º18E) 5♂, 3♀, 2-xi-2014, Leg. Zia.

Description: These naiads are elongated, hairy and pale brownish in color. Head almost broader than long and its hind angles slightly rounded. The prothorax is equal to the head; the lateral margins of the head bear a black spine, length of the hind legs are longer than 1st and 2nd pair of the legs, respectively. Mid dorsal hooks and small spines are present on terga 1-6. The lateral spines are very short, straight and equal in length, cerci equal to half the size of paraproct.

Habitat: These naiads were collected from slow-moving water of lakes and ponds. They were collected from the vegetation present inside and at the banks of water bodies. The dry temperature of the locality was 38ºC and while that of the water body was recorded as 25ºC.

Remarks: The diagnosis of this species and the habitat records match the description of Din *et al.,* (2013). The adults of this species are widely distributed in Pakistan and recorded in almost all provinces (Bhatti *et al.,* 2014; Chaudhry *et al.,* 2016; Din, 2012, Din *et al.,* 2013; Rafi *et al.,* 2009; Rehman *et al.,* 2020).

***Trithemis festiva* Rambur, 1842**

Material examined: (n=12, 6♂, 6♀). Loc. Chapar pul (1897ft., 33º39 N, 73º18 E) 4♂, 4♀, 2-vi-2014, Leg. Rehman; Loc. Jandala (2665ft., 33º42 N, 73º25 E) 2♂, 2♀, 2-iv-2014, Leg. Naeem.

Description: These naiads are blackish-brown in color and very small. The head is somewhat wider than long; its hind angles are rounded and bear spines on the posterior side. Wing pads parallel and reach the fourth abdominal segment, dark ring-like spots present on each leg. Abdominal segments 8 and 9 are comparatively longer than other segments and bear lateral spines, but the lateral spines on segment nine never reaching beyond half the length of the cerci. Dorsal spines on segment 6 are pointed and broader at the base. Paraproct is well developed**.**

Habitat: These naiads were collected in slow and fast-moving waters and from ponds. The dry temperature of the locality was 31ºC and while that of the water body was recorded 25ºC.

Remarks: The diagnosis of this species and the habitat records exactly tally with the previous description of Din (2012). However, the adults of this species are already documented from Khyber Pakhtunkhwa (Zada *et al.,* 2016; Chaudhry, 2010; Rehman *et al.,* 2020), Punjab (Din, 2012; Chaudhry *et al.,* 2016).

***Trithemis kirbyi kirby*i Selys, 1891**

Material examined: (n=16, 9♂, 7♀) Loc. Simly dam outflow stream (2010ft., 33°43 N, 73°14 E) 4♂, 2♀, 16-iv-2014, Leg. Naeem; Loc. Gokina. (3259ft., 33°47 N, 73°05 E) 2♂, 1♀, 2-vi-2014, Leg. Zia; Loc. Chapar pul.

(1897ft., 33º39N, 73º18E) 3♂, 4♀, 2-vi-2014, Leg. Rehman.

Description: These naiads are robust, smaller and pale yellowish in color. Head almost flat and two times wider than long. Eyes are medium and rounded; Labium and its hinge reach meso coxae, with a triangular median lobe. The prothorax is slightly narrower than the head. Wing pads parallel reaching to sixth abdominal segment. Legs thin, having dark marking present on each leg. The first and second pair of legs are almost equal in size but are much smaller than the hind legs. Abdomen with dorsal spines on segments 3-8 but segment 9 are vestigial, mainly strong and flattened.

Habitat: These naiads were collected from ponds and waters passing through the rocks. The dry temperature of the locality was 37ºC and while that of the water body was recorded 25ºC.

Remarks: The description of this species and the habitat records match with the description of Din (2013). This species is previously reported from Punjab and Baluchistan provinces (Chaudhry *et al.,* 2016; Din *et al.,* 2013).

***Crocothemis servilia* Drury, 1770**

Material examined: (n=17, 9♂, 8♀) Loc. Garam Thon (188ft., 33º45 N, 72º55 E) 1♂, 2♀, 24-iv-2014, Leg. Rehman; Loc. Gokina (3259ft., 33°47 N, 73°05 E) 2♂, 3♀, 30-iv-2014, Leg. Zia; Loc. Neela Sandh (2282ft., 33º39 N 73º23 E) 3♂, 2♀, 2-iv-2014, Leg. Naeem; Loc. Kallhya (1900ft., 33°33 N, 73°32 E) 3♂, 1♀), 10-vi-2014, Leg. Naeem

Description: Naiads are medium-sized transparent-bodied brownish in color. The head is almost broader than long; its hind angles are greatly rounded, with several hairs and pedicel. Labium reaches mesocoxae, the pre mental setae are 12, and the palpal setae are 11–13. Wing pads parallel reaching the abdominal segment seven. Legs are long, and the hind legs longer than the first and second pairs of legs. Abdomen without mid-dorsal spines, lateral spines present on segments 8–9. Paraprocts generally longer than epiproct. Cerci are about half the length of the paraproct.

Habitat These naiads were collected from slow-moving waters and ponds. The dry temperature of the locality was 32ºC and while that of the water body was recorded 25ºC.

Remarks: The morphology of this species and the habitat records match well with the description of Din (2012). The naiads are known from Punjab province (Din *et al.,* 2013). The adults of this species are reported from Khyber Pakhtunkhwa, Punjab and Baluchistan (Chaudhry *et al.,* 2016; Rehman *et al.,* 2020).

***Crocothemis erythraea* Brulle, 1832**

Material examined: (n=16, 10♂, 6♀). Loc. Gokina (3259ft., 33°47 N, 73°05 E) 2♂, 2♀, 30-iv-2014, Leg. Naeem; Loc. Phawandi Perchan (5954ft., 33º49 N, 73º29 E) 4♂, 2♀, 2-iv-2014, Leg. Zia; Loc. Jandala (2665ft., N, 33º42 N, 73º25 E) 4♂, 2♀, 2-vi-2014, Leg. Rehman.

Description: These naiads are smaller in size. Head broader than long and hind angles greatly rounded and covered with long. Premental setae are about 13–15 and palpal setae are 10–11. The prothorax is shorter than the head. Wing pads are parallel reaching the fifth abdominal segment. Legs are long in size, and the hind legs are not reaching the abdomen's apex. The abdomen is without a mid-dorsal spine; lateral spines are present on segments 8 and 9. Epiproct is generally shorter than paraprocts and cerci length equal to half the size of the paraproct.

Habitat: Naiads were captured from the banks of slow-moving and stagnant water pockets along the bases of rocks carrying aquatic flora. The dry temperature of the locality was 30ºC, while that of the water body was recorded 27ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). This species is previously reported from Punjab province (Din *et al.,* 2013). The adults of this species are reported from Khyber Pakhtunkhwa, Punjab and Baluchistan (Chaudhry, 2010; Rehman *et al.,* 2020).

***Pantala flavescens* Fabricius, 1798**

Material examined: (n=38, 23♂, 19♀). Loc. Angoory Forest Stream-II (3746ft., 33°48 N 73°21 E) 10♂, 6♀, 10-vi-2014, Leg. Naeem; Loc. Garam Thon (188ft., 33º45 N, 72º55 E) 5♂, 4♀, 24-iv-2014, Leg. Zia; Loc. Khanpur Dam (2002ft., 33°49 N, 72°55 E) 8♂, 9♀, 10-vii-2014, Leg. Naeem.

Description: Naiads are smooth and dark brown in color. The head is longer than broad and hind angles are rounded. A large number of hairs present at the posterior corner. Eyes are large, reaching to the base of the antennae. Antennae are seven segmented, 1st segment is smaller than 2nd segment. The labial hinge reaches up to the second pair of legs. Wing pads parallel reaching up to the 6th abdominal segment. Black spots are present on the legs but the legs are without hairs; the hind leg is longer reaching beyond the apex of the abdomen. Epiproct is smaller than paraproct and cerci about half the length of paraproct**.**

Habitat: These naiads were collected from small water ponds. The dry temperature of the locality was 32ºC and while that of the water body was recorded 26ºC.

Remarks: The diagnosis of this species and the habitat records tally with the description of Din (2012). This species is widely distributed in Pakistan and the adults of this species are recorded in almost from each province

(Bhatti *et al.,* 2014; Chaudhry *et al.,* 2016; Din, 2012; Din *et al.,* 2013; Rafi *et al.,* 2009; Rehman *et al.,* 2020; Yousuf, 1972).

***Sympetrum fonscolombei* Selys, 1840**

Material examined: (n=14, 8♂, 6♀). Loc. Rata Kas (2750ft., 33°43 N, 73°27 E) 5♂, 3♀, 10-iv-2014, Leg. Naeem; Loc. Jandala (2665ft., 33º42 N, 73º25 E) 3♂, 3♀, 2-vi-2014, Leg. Rehman.

Description: These naiads are smaller in size and dark brownish in color. The head is small and the eyes are slightly pointed on the inner side and rounded in shape. The labial hinge is reaching to the first pair of legs. Antennae are seven segmented all segments are uniform in length. The premental setae are 14–16 and pulpal setae are 12–14. The prothorax is equal to the head size. Wing pads parallel and reach the center of the sixth and seventh abdominal segments. Legs are covered with black spots. Epiproct is smaller than paraproct. Cerci are smaller than the length of paraproct.

Habitat: These naiads were found in slow-moving, stagnant water bodies and were also encountered from the vegetation present at the brinks of the slow-moving water of the ponds. The dry temperature of the locality was 38ºC, while that of the water body was recorded 27ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din, (2012). The adult and naiads of this species are already documented from Punjab province (Chaudhry *et al.,* 2016; Din *et al.,* 2013).

***Selysiothemis nigra* Vander Linden, 1825**

Material examined: (n=11, 6♂, 5♀) Loc. Chapar Pul (1897ft., 33º39 N, 73º18 E) 2♂, 2♀, 30-vi-2014, Leg. Rehman; Loc. Rumli (2421ft., 33°46 N, 73°8 E) 4♂, 3♀, 2-iv-2014, Leg. Naeem.

Description: Body medium-sized. The head is two times longer than wide and bearing small setae. The labial suture in the resting position reaching to middle coxae. Antennae 6–7 segmented. Labial palpi with at least nine setae. Wing pads parallel reaches to the sixth abdominal segment; small hairs are present on the legs, size long and slender. Black spots are present on the legs; hind legs are longer than the first and second legs. Paraproct is larger than epiproct. Cerci are more than half the length of paraproct.

Habitat: Naiads were encountered from moving waters with lots of grasses. Dry temperature of locality was 34ºC, while that of water body was recorded 26ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). This naiad of this species has been previously reported from Punjab by (Din *et al.,* 2013), while the adults are documented from Sindh by (Chaudhry *et al.,* 2016).

***Rhyothemis variegata* Linnaeus, 1763**

Material examined: (n=6, 3♂, 3♀). Loc. Gokina (3259ft., 33°47 N, 73°05 E) 1♂, 2♀, 30-iv-2014, Leg. Naeem; Loc. Manga (3835ft., 33º50 N, 73º20 E) 2♂, 1♀, 16-viii-2014, Leg. Rehman.

Description: These naiads are strongly sclerotized and smaller, covered with small hairs and brownish color. The head is smaller in size. Eyes are normal, their posterior margin concave and a dark brown spot present at the inner side. Third antennal segment is longer than the fourth. Labium with its hinge is reaching between procoxae. Lateral setae are seven, and pre mental setae are 11–13. Legs femora and tibiae encircled with black line. Dorsal hook present on segments 2–9, lateral spine is short and cerci reaching half the length of paraproct.

Habitat: These naiads were collected from ponds. These were shady spots with dense aquatic vegetation. The dry temperature of the locality was 32ºC and while that of water body was recorded 25ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan, but the adult habitat is similar to current research. This species' adult is previously reported from Punjab province (Chaudhry *et al.,* 2016).

Suborder Zygoptera

Family Chlorocyphidae Cowley, 1937

***Rhinocypha quadrimaculata* Selys, 1853**

Material examined: (n=9, 5♂, 4♀). Loc. Chapar pul (1897ft., 33º39 N, 73º18 E) 2♂, 1♀, 2-viii-2014, Leg. Rehman; Loc. Kurri (1821ft., 33°41 N, 73°10 E) 1♂, 2♀, 30-iv-2014, Leg. Naeem; Loc. Kathar Bobry (2706ft., 33º64 N, 73º18 E) 2♂, 1♀, 10-vi-2014, Leg. Zia.

Description: These naiads are medium in size and black brownish. Head almost longer than broad. Eyes are small dark brown and the labium suture reaches the forelegs. Prementum setae are four, and pulpal setae are only six. The prothorax is slightly smaller than the hind margins of the head. Wing pads are strongly divergent, reaching beyond the fourth abdominal segment. Hind legs reach the abdomen apex and are longer than the first and second pair of legs. The abdomen is five times longer than wide in full-grown larvae and two caudal gills, and the gills are transparent and bear small dots or spots.

Habitat: These naiads were collected from water running between the mountains. The spot was covered with trees and long grasses. The dry temperature of the locality was 35ºC and while that of the water body was recorded as 29ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan, but the adult habitat is similar to current research. The adults of this species are previously reported from Punjab province and Azad Kashmir by (Zia, 2010) and Khyber Pakhtunkhwa (Rehman *et al.,* 2019).

Family Coenagrionidae

***Pseudagrion decorum* Rambur, 1842**

Material examined: (n=15, 8♂, 7♀). Loc. Jandala (2665ft., 33º42 N, 73º25 E) 1♂, 2♀, 2-vi-2014, Leg. Naeem; Loc. Laacha (2181ft., 33°42 N, 73°20 E) 1♂, 2♀, 25-iv-2014, Leg. Naeem.

Description: These naiads are medium in size, brownish in color, and their body is smooth without hairs. Head almost broader than long. Antennae seven segmented. Labium hinge is reaching to meso-coxae. The prothorax is narrower than the head. Wing pads parallel, reaching behind to the fourth abdominal segment. Legs are short, reaching up to the sixth abdominal segment. The abdomen is much longer than wide in full-grown larvae. Many small sclerotized spines are present on the body.

Habitat: The naiads were collected from stagnant water pockets. Bushes and wild vegetation were present around all collection spots. Dry temperature of locality was 32ºC and while that of water body was recorded 25ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). The naiads of this species are previously reported from Punjab by (Din *et al.,* 2013), while the adults are reported from Punjab and Khyber Pakhtunkhwa provinces (Zia *et al.,* 2011a; Rehman *et al.,* 2019)

***Pseudagrion laidlawi* Fraser, 1922**

Material examined: (n=14, 6♂, 8♀). Loc. Aliyot (5002ft., 33º57 N, 73º28 E) 2♂, 4♀, 16-x-2014, Leg. Zia; Loc. Chapar pul (1897ft., 33º39 N, 73º18 E) 3♂, 2♀, 2-xi-2014, Leg. Zia; Loc. Qalandar Kassi (3996ft., 33º59 N, 73º29 E) 1♂, 2♀, 16-vi-2014, Leg. Rehman.

Description: Naiads are medium-sized and pale brown. Head somewhat broader than long; its hind angles rounded containing a row of small spines on the posterior side of eyes. Wing pads reach to third abdominal segment. Legs thin, with a dark marking, are present on the leg; the first and second pair of legs are almost equal in size but are much smaller than the hind leg. The abdomen is without mid-dorsal spines. Caudal gills are transparent and possess a strong midrib that ends with a rounded apex.

Habitat: The naiads were collected from slow-moving and standing water pockets. The area was covered with tall trees and high rocks. The dry temperature of the locality was 34ºC, while that of the water body was recorded 20ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan, but the adult habitat is similar to current research. The adult is previously reported from Punjab, Azad Jammu and Kashmir, Khyber Pakhtunkhwa and Sindh provinces (Zia *et al.,* 2011a; Zia, 2010).

***Pseudagrion spencei* Fraser, 1922**

Material examined: (n=13, 7♂, 6♀). Loc. Mangla Dam (1538ft., 33º00 N, 73º51 E) 3♂, 2♀, 11-vi-2014, Leg. Zia; Loc. Batala (1825ft., 33°34 N, 73°24 E) 2♂, 3♀, 22-viii-2014, Leg. Naeem; Loc. Ali beig/Jaatla (1785ft., 33º01 N, 73º51 E) 2♂, 1♀, 11-vi-2014, Leg. Naeem.

Description: Naiads are smaller in size and pale yellowish. Head somewhat broader than long. Antennae are 7 segmented. The prothorax is slightly narrower than the hind margins of the head. Wing pads parallel reaching to second abdominal segment. Legs are very short, with dark markings after a certain gap on each leg; the first and second pair of legs are almost equal in size but are much smaller than the hind leg. The abdomen is ten segmented without mid-dorsal spines. Caudal gills are transparent, and each gill has a strong midrib that ends with a rounded apex.

Habitat: The specimens were collected from moving and standing waters of rocks. The dry temperature of the locality was 38ºC and while that of the water body was recorded 32ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). The naiads of this species are previously reported from Punjab province by (Din *et al.,* 2013), while the adults are documented from Punjab, Azad Jammu and Kashmir, Khyber Pakhtunkhwa (Zia *et al.,* 2011a).

***Ceriagrion coromandelianum* Fabricius, 1798**

Material examined: (n=15, 7♂, 8♀). Loc. Lakot (4111ft., 33°53 N, 73°23 E) 4♂, 3♀, 16-x-2014, Leg. Naeem; Loc. Bostal (2740ft., 33º49 N, 73º20 E) 3♂, 5♀, 22-viii-2014, Leg. Rehman.

Description: These naiads are robust, medium-sized, and blackish-brown in color. The head is almost broader than long, its hind angles rounded or nearly so, containing small spines. Eyes medium-sized and raised upward. Antennae seven segmented. Wing pads reaching up to the fourth abdominal segment. Small hairs present on legs, 1st and 2nd pair of legs is almost equal in size but are much smaller than the hind leg. The abdomen is ten segmented without mid-dorsal spines. Caudal gills are delicate and long.

Habitat: The naiads were collected from stagnant water pockets. The spot was covered with dense vegetation of pine trees. Dry temperature of the locality was 35ºC and while that of the water body was recorded 29ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). This species is widely distributed in almost all provinces of Pakistan. In previous studies, the adults are reported from Azad Jammu and Kashmir, Khyber Pakhtunkhwa (Zia, *et al.,* 2011a; Rehman *et al.,* 2019), Gilgit Baltistan (Zia *et al.,* 2009) and Punjab (Zia, 2010; Bhatti *et al.,* 2014; Din *et al.,* 2013).

Family Calopterygidae Selys, 1850

***Neurobasis chinensis* Linnaeus, 1758**

Material examined: (n=8, 4♂, 4♀) Loc. Wah Garden 2♂, 3♀, 11-ix-2014, Leg. Naeem; Loc. Ali beig/Jaatla (1785ft., 33º01 N, 73º51 E) 2♂, 1♀, 11-vi-2014, Leg. Naeem.

Description: The body of naiads is large, slender and dark brown to black. The head is almost broader than long, flat and pentagonal with hind angles rounded. Eyes large in size and raised upward. Antennae three-segmented, scape is two-time longer than pedical, both are slightly brownish. The labial mask is short, but the prementum produced a deep cleft with small dorsal setae. Premental and palpal setae absent. Legs are long with no hairs, the first and second pair of legs are not equal, but hind legs are long and reach the apex of the abdomen. The abdomen is ten segmented without mid-dorsal spines blackish spots on each segment. Caudal gills are strong, long in size and have strong midrib, which looks like veins of the leaf.

Habitat: The naiads were collected from running water. Few specimens were recorded from a small lake passing through small mountains covered with dense vegetation of pine trees and wild grasses. Dry temperature of the locality was 27ºC and while that of the water body was recorded 23ºC.

Remarks: In previous studies, no record is found for the naiads of this species from Pakistan, but the adult habitat is similar to current research. This adult was recorded from Punjab (Zia, 2010), Khyber Pakhtunkhwa (Zada, 2016; Zia *et al.,* 2011a; Rehman *et al.,* 2019), Azad Jammu and Kashmir (Zia, 2010).

Family Lestidae Calvert, 1901

***Lestes patricia* Fraser, 1924**

Material examined: (n=6, 5♂, 1♀) Loc. Angoory Bridge spot (3835ft., 33º47 N, 73º21 E) 2♂, 10-vi-2014, Leg. Naeem; Angoory Forest Stream-I (2394ft., 33°46 N, 73°16 E) 3♂, 1♀, 20-vi-2014, Leg. Iqbal.

Description: These naiads are slender and longer in size, color often light green or brown, sometimes quite dark. The head is two times broader than long; its hind angles are rounded. The flagellum is longer than the combined length of the scape and pedicel. Labium hinge is reaching to mesocoxae. The prothorax is narrower as compared to the head. Wing pads reach the third abdominal segment. Legs are short, the hind leg longer than the pro and meso legs, meso leg smallest of all. The abdomen is subcylindrical, having lateral spines on segments 6-9. Caudal gills are long and transparent, lack marginal setae, tracheae nearly perpendicular to the axis and branched near the margins.

Habitat: These naiads were collected from small water pockets within the mountains; the spot was covered with trees and long grasses. Dry temperature of the locality was 32ºC and while that of the water body was recorded 26ºC.

Remarks: The morphology of this species and the habitat records exactly tally with the description of Din (2012). The adults are earlier reported from Azad Jammu and Kashmir (Rafi *et al.,* 2009).

DISCUSSION

Present study was conducted to bring forward Odonata naiads inhabiting sub-Himalayan foothills of Pakistan as a primitive work for the subject area and subject group. In contrast to adults, Odonata naiads got little attention from taxonomists and biologists all over the globe. Within Pakistan, thorough studies conducted over odonate naiads are very few. Yet, scattered information based on single to few species is available in some local publications. The immatures really matter to document the actual species composition of any flying group for any specific area. Din *et al.,* (2013) also stressed that Odonata fauna of any area reported based on adults did not present an actual picture of the inhabiting species of that area. The odonates tend to fly miles in search of food and other requirements like temperature and humidity (Silsby, 2001). In another study, Zia *et al.,* (2011b) stated that endemism in flying insects, especially Odonata, cannot be rightly claimed until and unless its larvae (naiads) are recorded from that particular region. In this regard, it is important to state that the foothills of the Himalayas falling under Pakistan are never surveyed for Odonata naiads. Yet, the adults are recorded by Raza (2015), Naeem (2016) and Zia (2016). The present manuscript is the actual outcome of Naeem (2016). These foothills of Himalaya, present in the form of a continuous hill range under administrative boundaries of three districts (Rawalpindi, Islamabad, Attock) of Punjab province, one district (Mir Pur) of Azad Jammu and Kashmir (AJK) and two districts (Haripur and

Abbottabad) of Khyber Pakhtunkhwa province were surveyed during the present study.

There exist unlimited water bodies in the form of perennial springs, seasonal streams, village ponds, lakes, and rivers that naturally support the complex of Odonata. The area has many valleys and villages which are difficult to reach and thus present undisturbed ecology. Reduced anthropogenic activities are noticed in these valleys and villages. The present study came up with a record of 23 species of dragonfly and damselfly naiads. However, previously conducted works on Odonata naiads of the country together reported 40 species (Fig. 3). If the results of the present study are compared with previous records of Odonata naiads in Pakistan, it is evident that this hill belt alone provided more than 50% of the Odonata naiad's fauna in the country. It highlights the importance of these hills and the thirst for conducting more deep surveys in the valleys and high up the hills throughout the Himalayas in Pakistan.

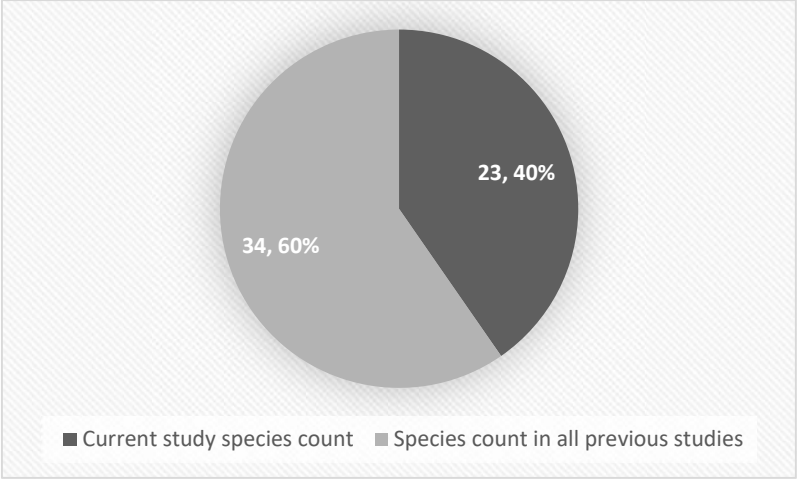

Fig. 3. Species count for Odonata naiads (Current work vs. previous works)

In the current study, the effect of altitudinal clines over species distribution was also studied. For this, data for altitude was divided into three categories. The first category represented altitude <2000ft, the second category shows 2000ft to 3999ft height from sea level, whereas the third category ranges between 4000ft to 6000ft. Results (Fig. 4) show a clear trend in species richness with a change in altitude. It was noticed that species count increases with the increase in altitude, yet it tends to decrease after a certain height, i.e., 4000ft. These findings are in accordance with Zia (2016), who stated 2000ft to 4000ft as the most optimum altitude for Odonata life and biology. In another work, Raza (2015) stated that at altitudes higher than 4000ft, the species count of Odonata decreases due to low temperature and humidity conditions. He emphasized that Odonata prefers warmer to hot climates. Hardy *et al.,* (2001) also documented a significant effect of altitude over species richness. After a certain limit, it declines even with a 100-meter increase in altitude. Temperature and humidity have a direct relationship with altitude and being heat lovers, Odonata life has a strong relationship with these physiological factors.

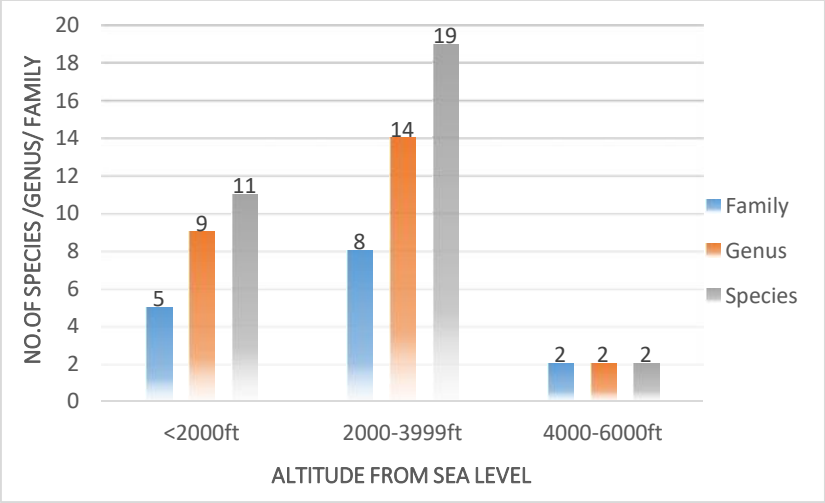

Fig. 4. Effect of altitude over the distribution of Odonata naiads in Himalayan foothills of Pakistan

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